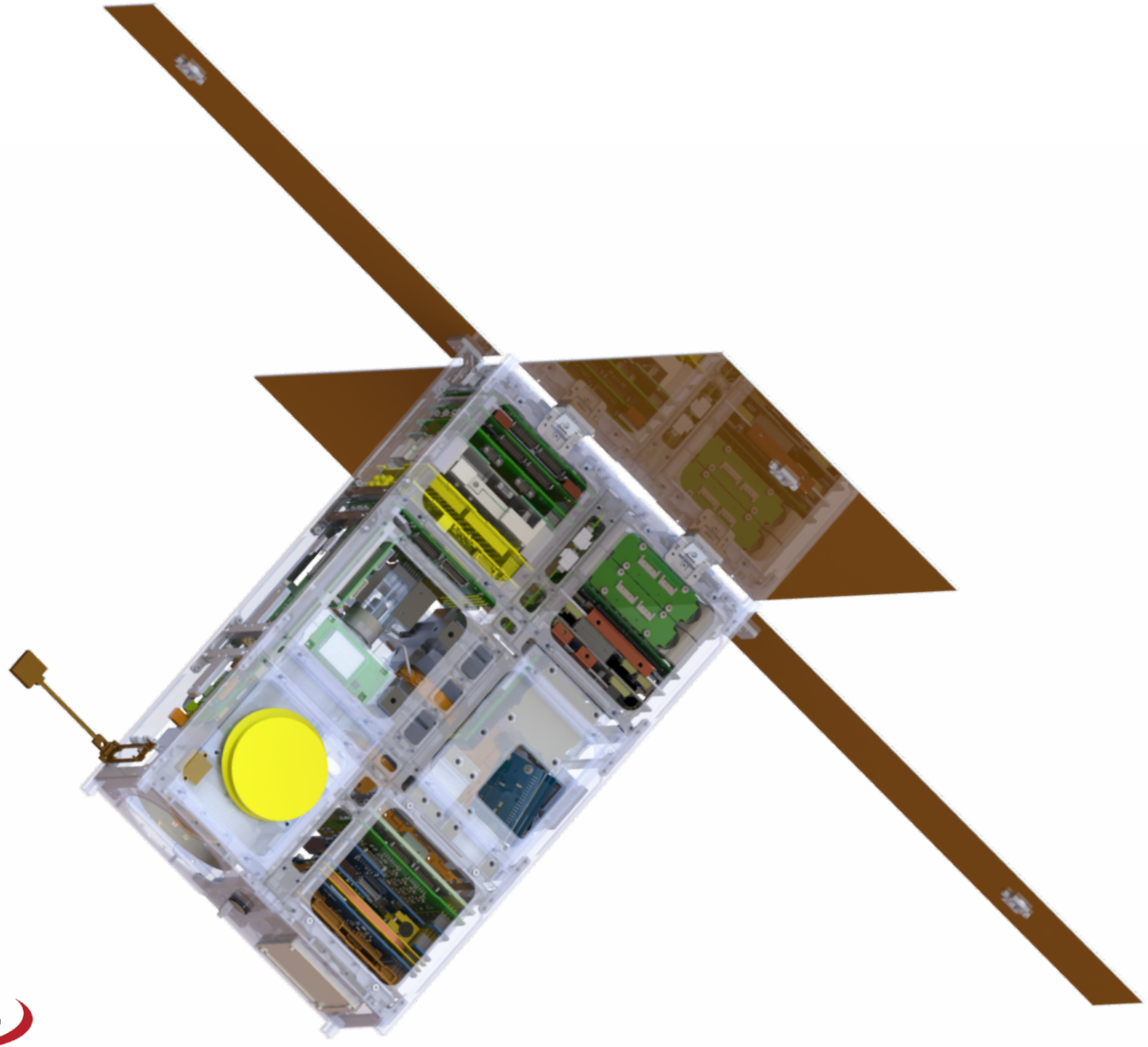
HyTI: high spectral and spatial resolution thermal infrared imaging from a 6U CubeSat



Presented by

Robert Wright

Hawai'i Institute of Geophysics and Planetology,
University of Hawai'i at Mānoa

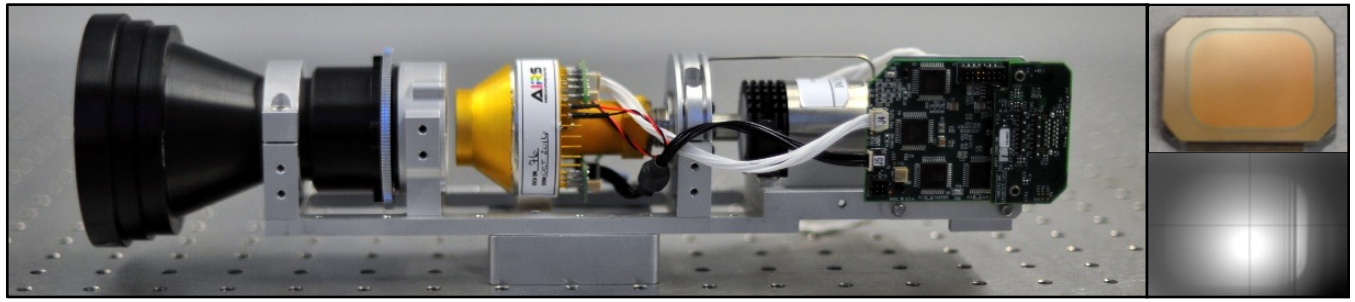
On behalf of the HyTI Team

HyTI Mission Goals

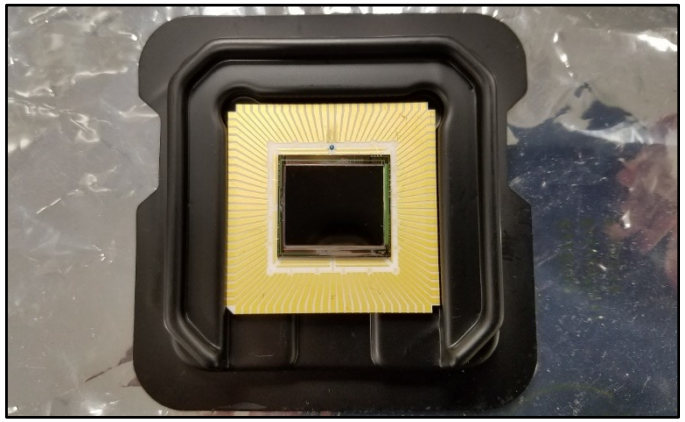
HyTI
Hyperspectral Thermal Imager

To demonstrate **high spectral, high spatial, and high SNR long-wave infrared imaging**, and **high performance on-board computing** to process the resulting data, on a **6U CubeSat** platform

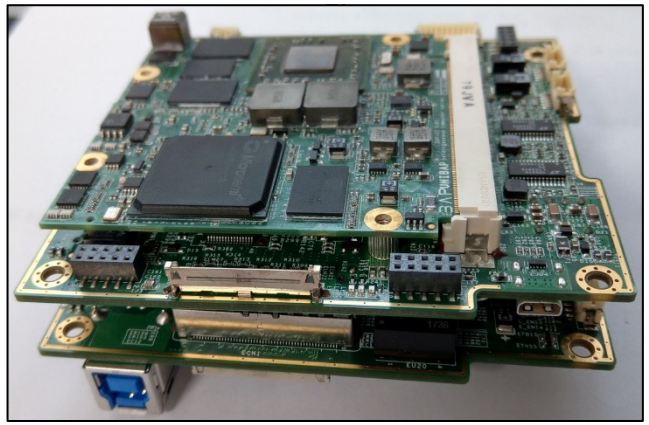
1. HIGP Fabry-Perot LWIR imaging interferometer (TRL_{in} = 4)

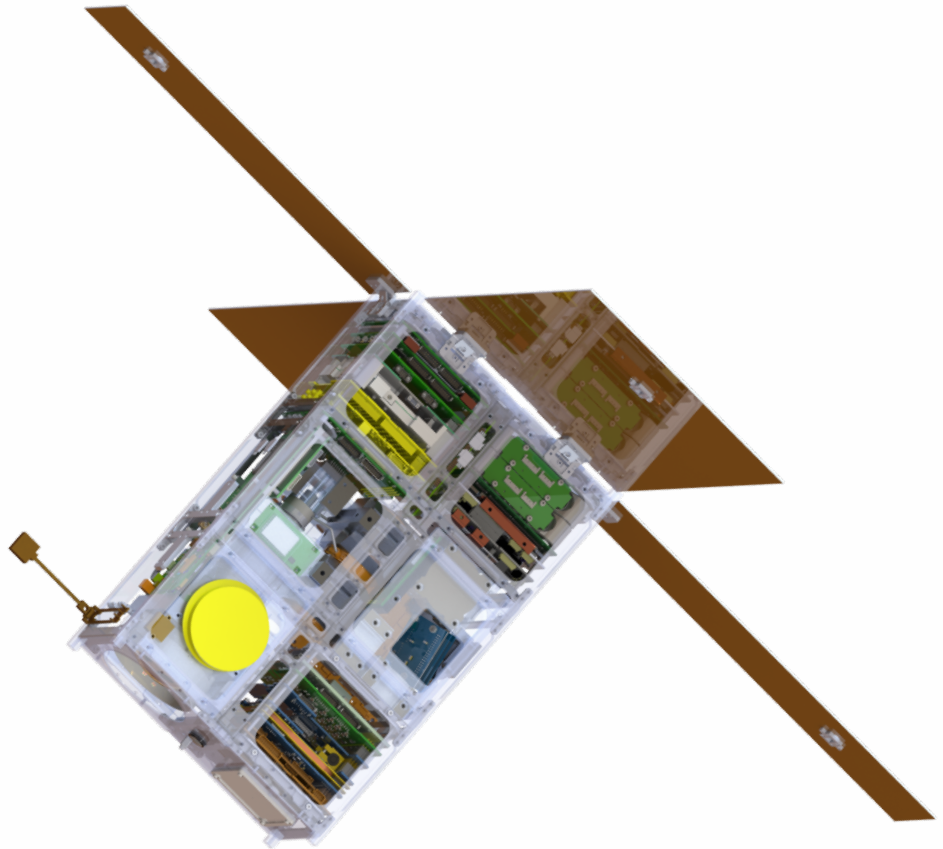


2. JPL T2SLS Barrier InfraRed Detector (BIRD) focal plane array (TRL_{in} = 5)



3. Unibap Deep Delphi iX5 heterogeneous onboard computer (TRL_{in}

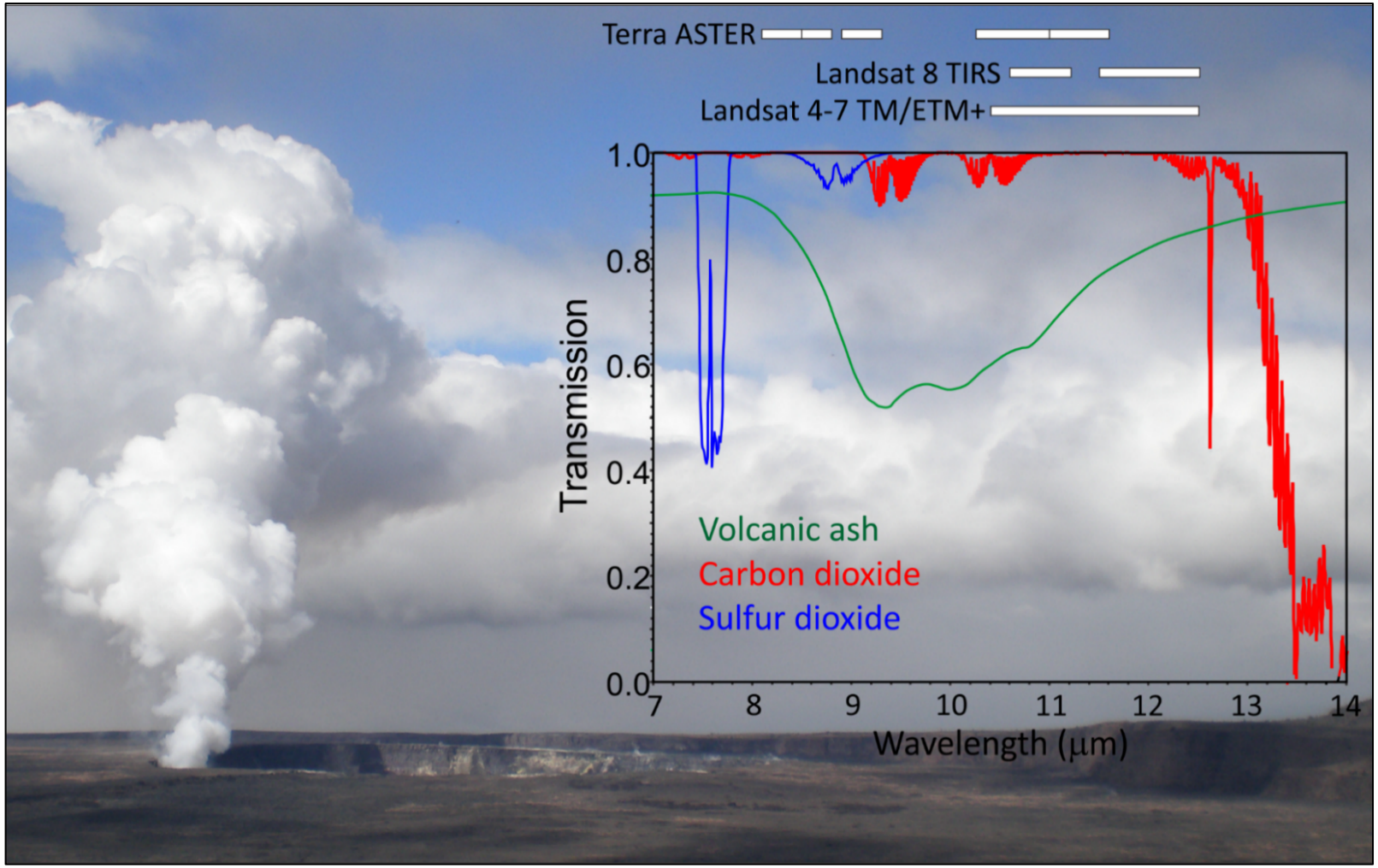




Relevance of HyTI to NASA's Earth Science mission

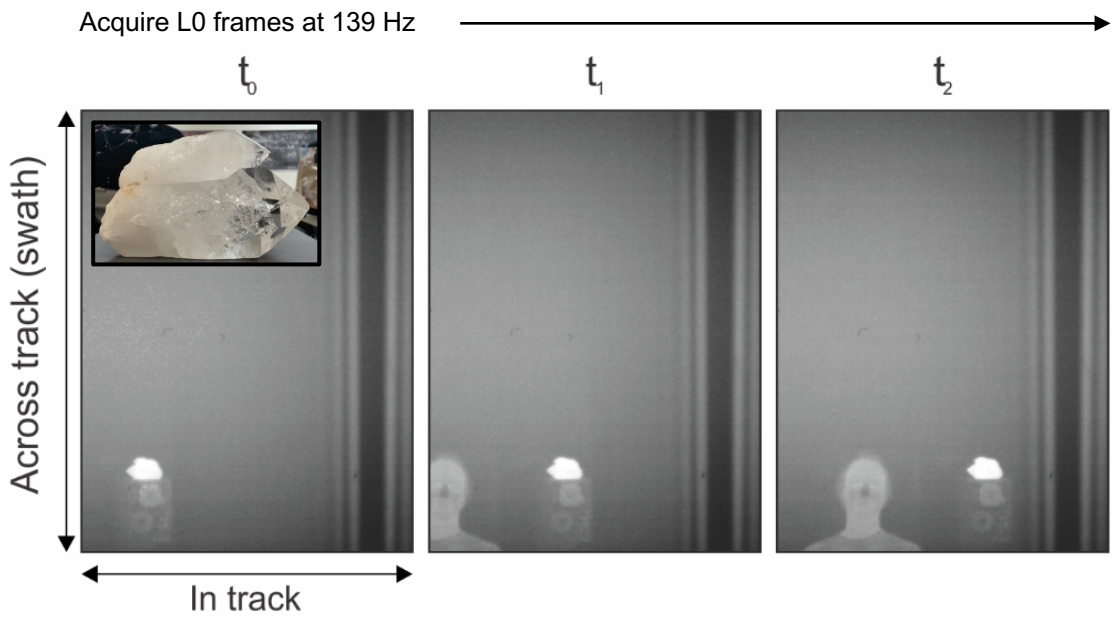
HyTI
Hyperspectral Thermal Imager

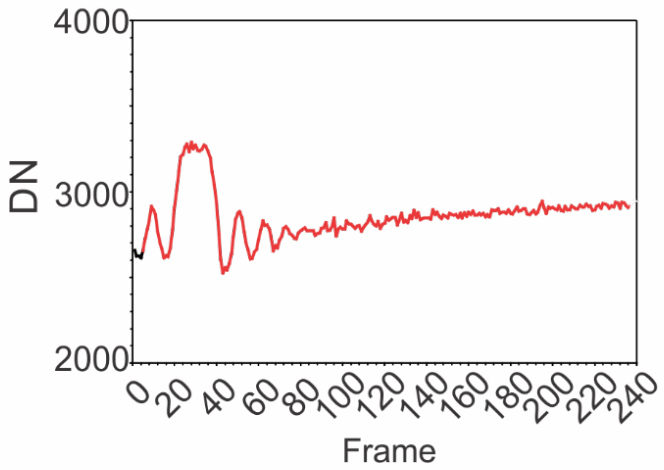
Earth scientists have never had access to high spatial and high spectral longwave infrared image data from Earth orbit

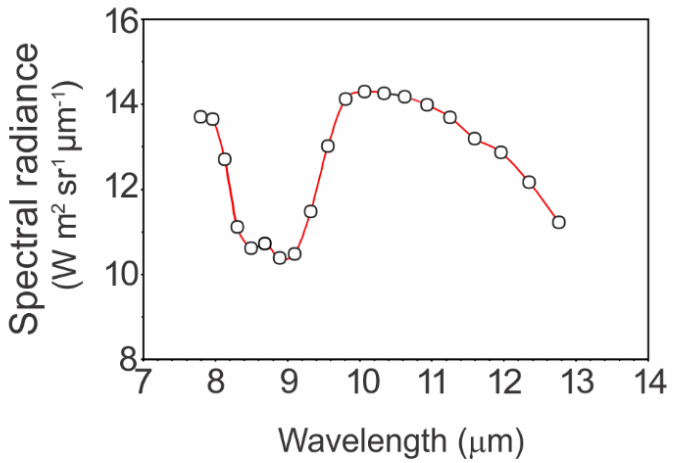


HyTI Science Measurement Approach

HyTI
Hyperspectral Thermal Imager

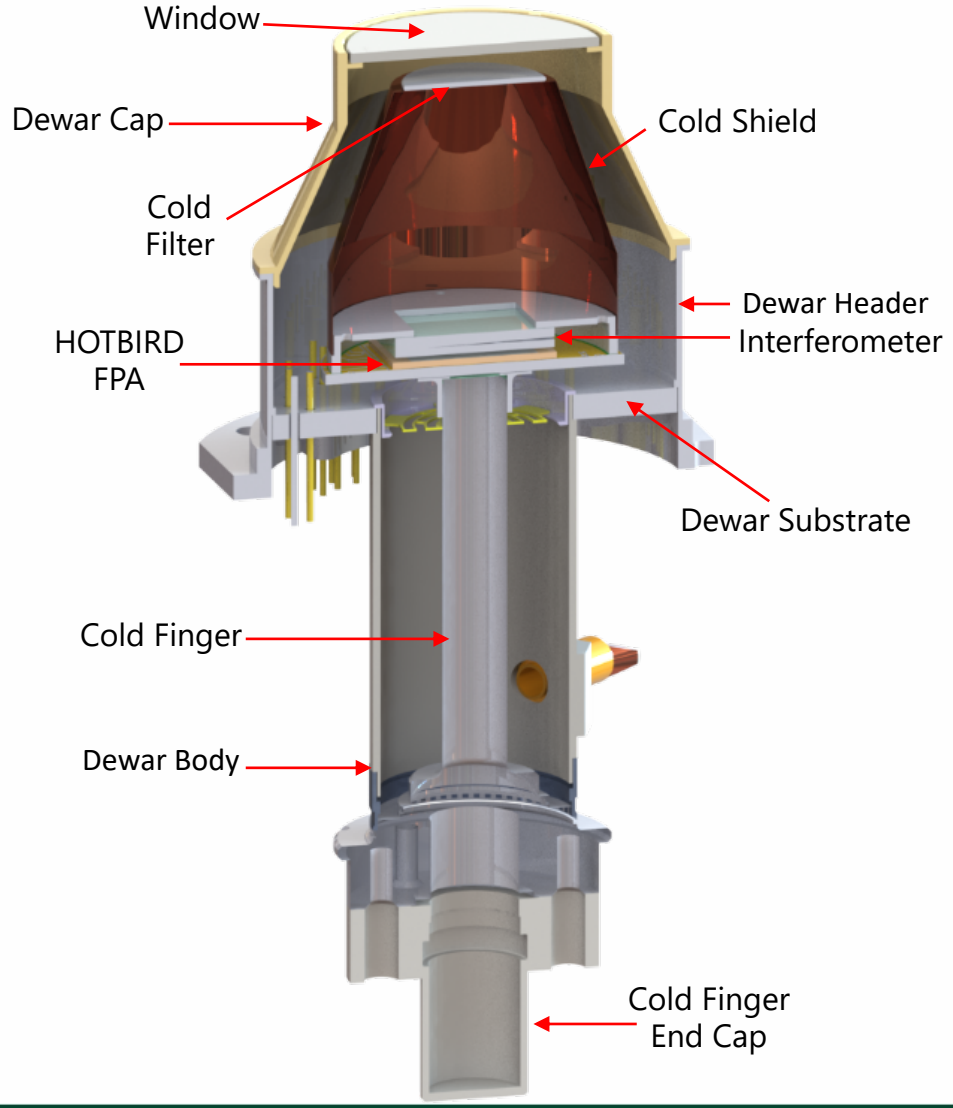


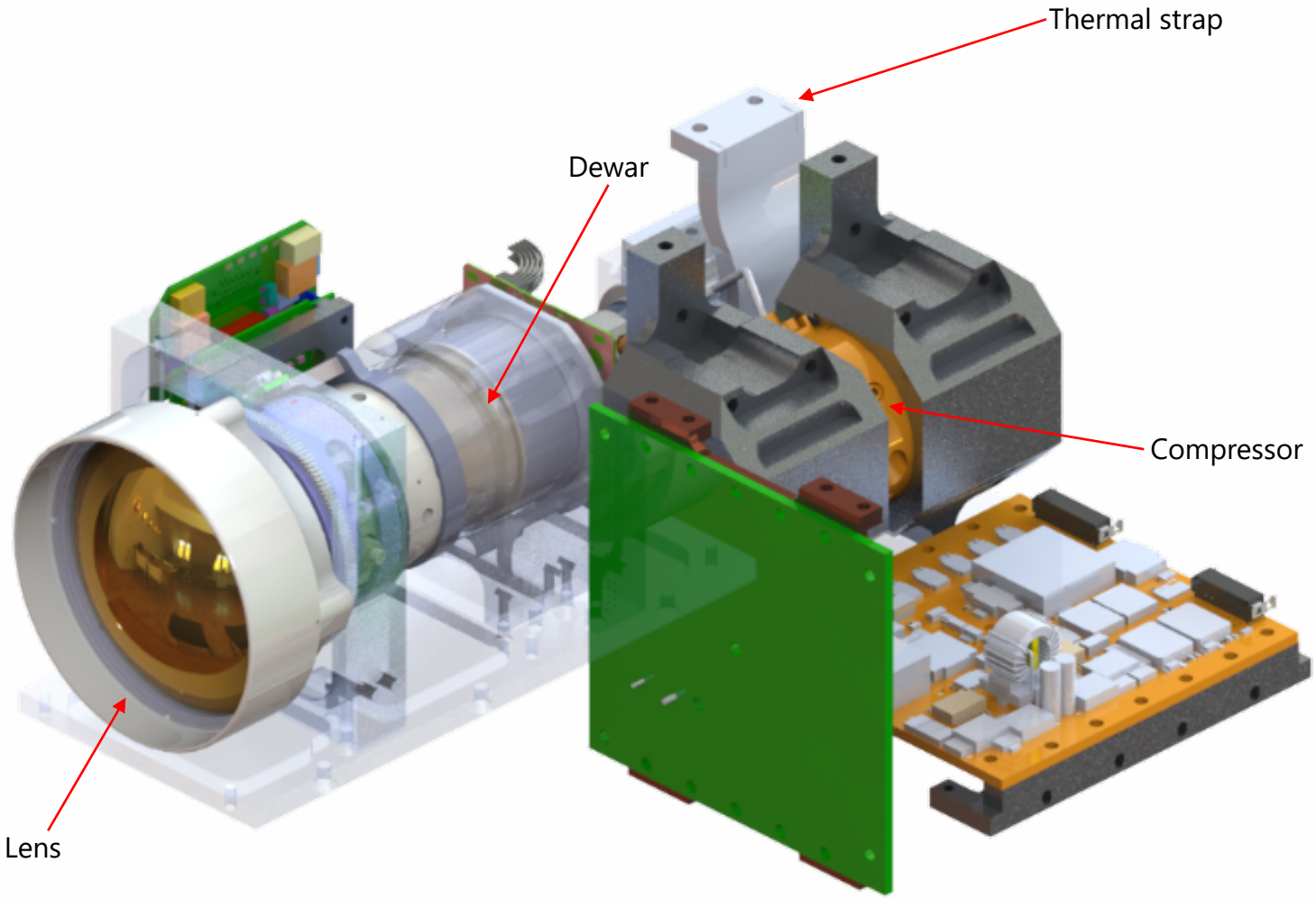




HyTI Thermal Infrared Interferometric Imaging Spectrometer

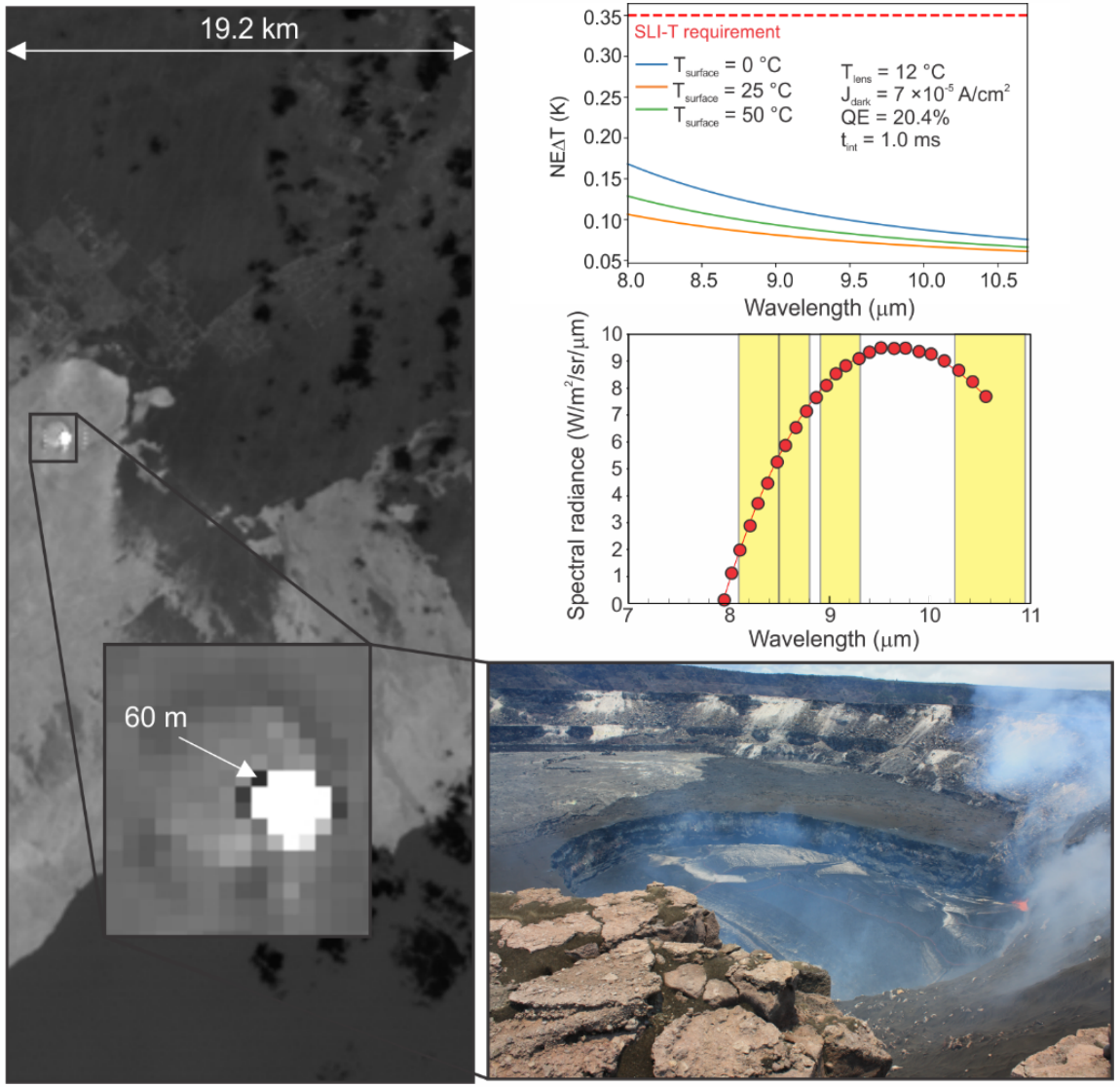
HyTI
Hyperspectral Thermal Imager

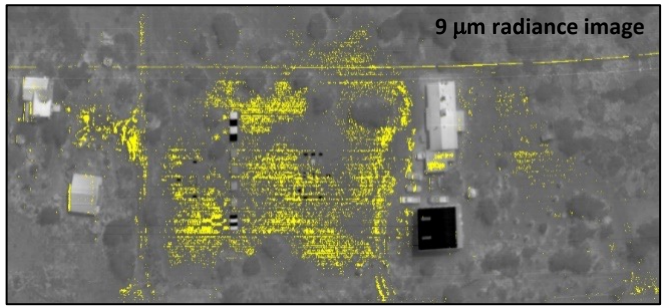


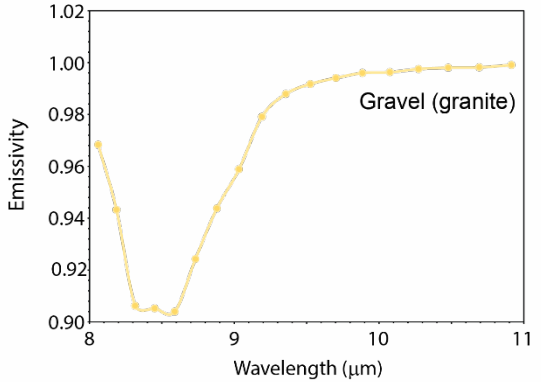


What HyTI data will look like

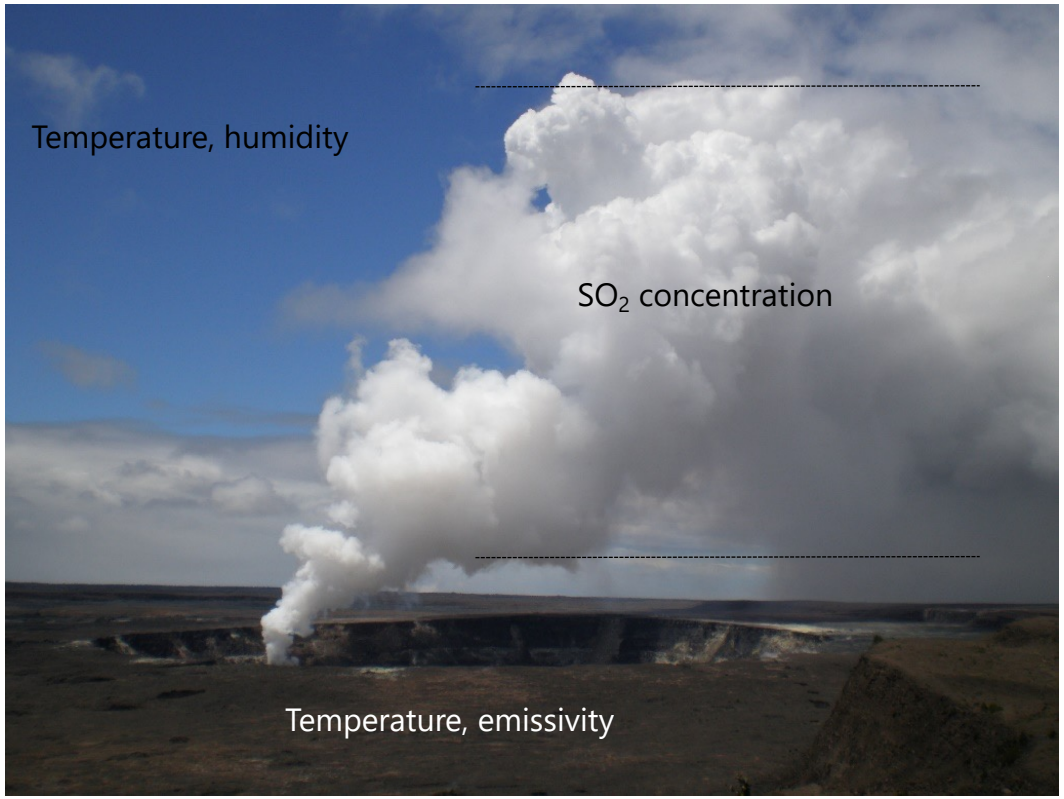
HyTI
Hyperspectral Thermal Imager

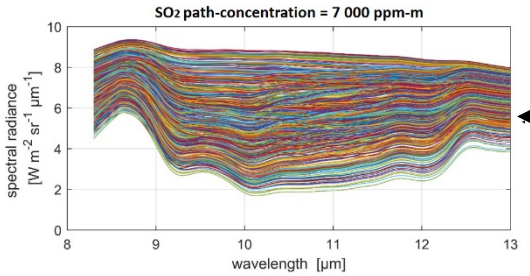






L2 science products will be generated on-board HyTI

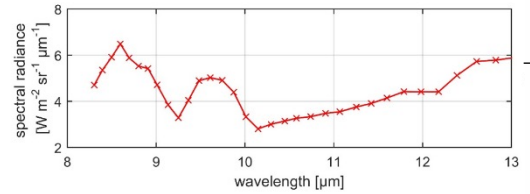




Training

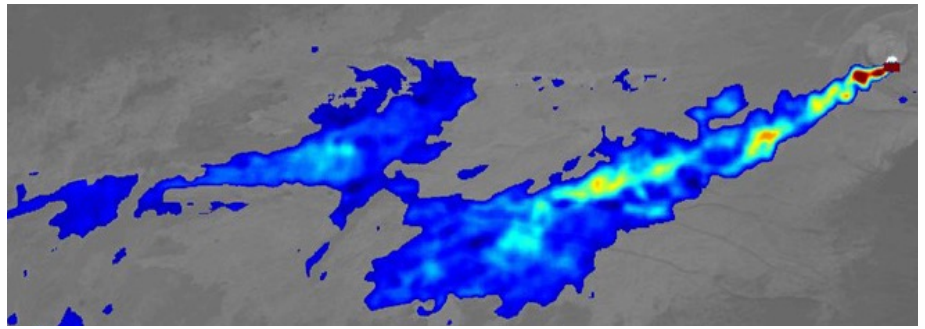
$SO_2(known) = \alpha_1 L_1 + \alpha_2 L_2 + \cdots + \alpha_{25} L_{25}$ ⟷ $SO_2(known) = n$ ppm.m

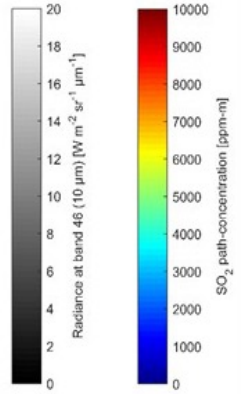
$$\alpha_1 = \begin{pmatrix} \alpha_{1,1} \\ \cdots \\ \alpha_{k,1} \end{pmatrix}, \ldots$$



Validation and implementation

$SO_2(unknown) = \alpha_1 L_1 + \alpha_2 L_2 + \cdots + \alpha_{25} L_{25}$ → $SO_2(unknown) = ?$ ppm.m

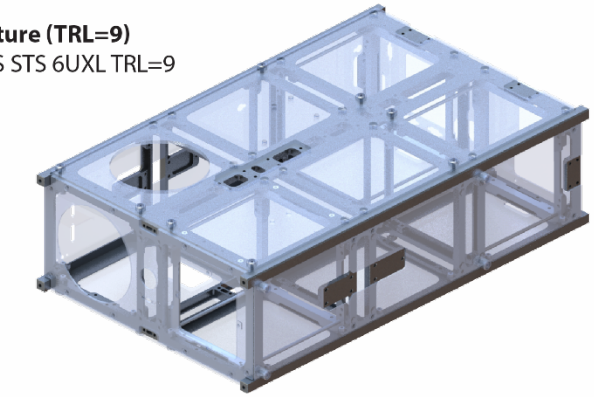


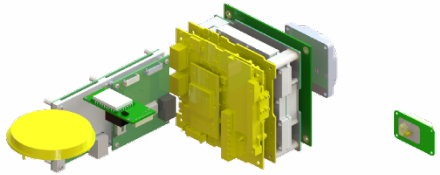


HyTI spacecraft subsystems

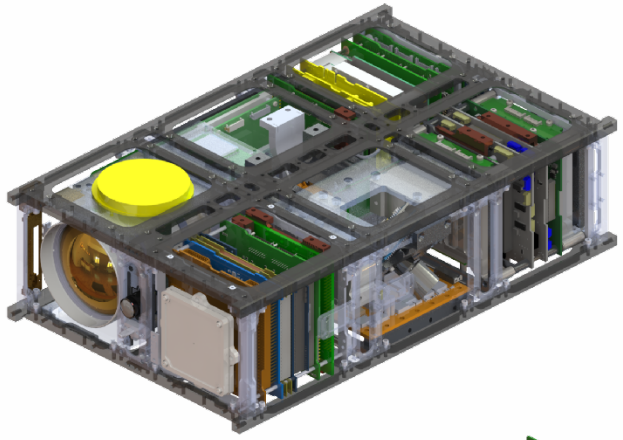
HyTI
Hyperspectral Thermal Imager

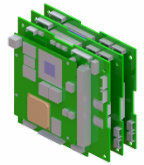
Structure (TRL=9)
- ISIS STS 6UXL TRL=9





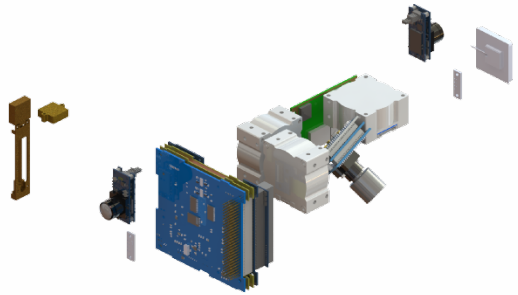
Communications (TRL=5)
- X-band downlink (Syrlinks EWC27) TRL=9
- X-band patch antenna (SPAN-X-T3) TRL=9
- S-band transceiver (ISIS) TRL=5
- S-band patch antenna (ISIS) TRL=5
- GlobalStar duplex (NSL EyeStar-D2) TRL=9
- Global Star simplex (NSL EyeStar-S3 (STX3)) TRL=8

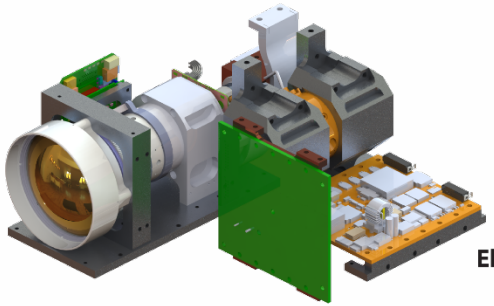


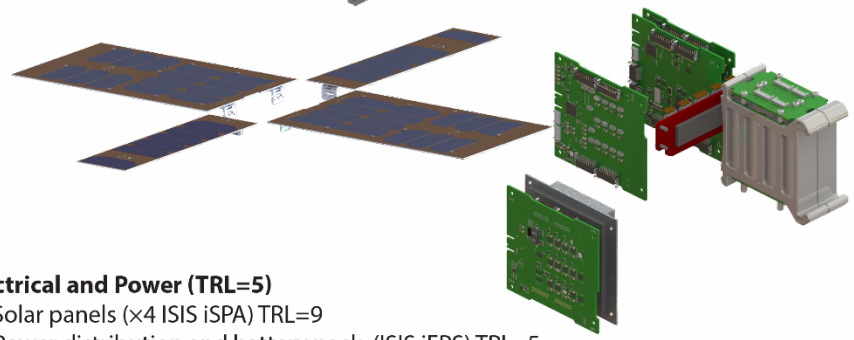


Command and Data Handling (TRL=5)
- Payload OBC (Unibap DD-iX5) TRL=5
- Spacecraft OBC (ISIS iOBC) TRL=9

Payload (TRL=4)
- Multi-element lens (NEOS/FLIR) TRL=6
  - Focus motor (Faulhaber AM1020) TRL=4
- Fabry-Perot interferometer (LightMachinery) TRL=6
- BIRD FPA (JPL) TRL=5
- Integrated dewar cooler assembly (AIRS) TRL=4
  - Dewar assembly (AIRS hi-Nyx) TRL=4
    - SiF board (AIRS) TRL=4
    - Dewar board (AIRS) TRL=4
    - Camerlink interface board TRL=4
  - Cryocooler (AIM SF070) TRL=4
  - Cryocooler drive electronics (Creare) TRL=5
- Current ripple filter (Creare) TRL=5





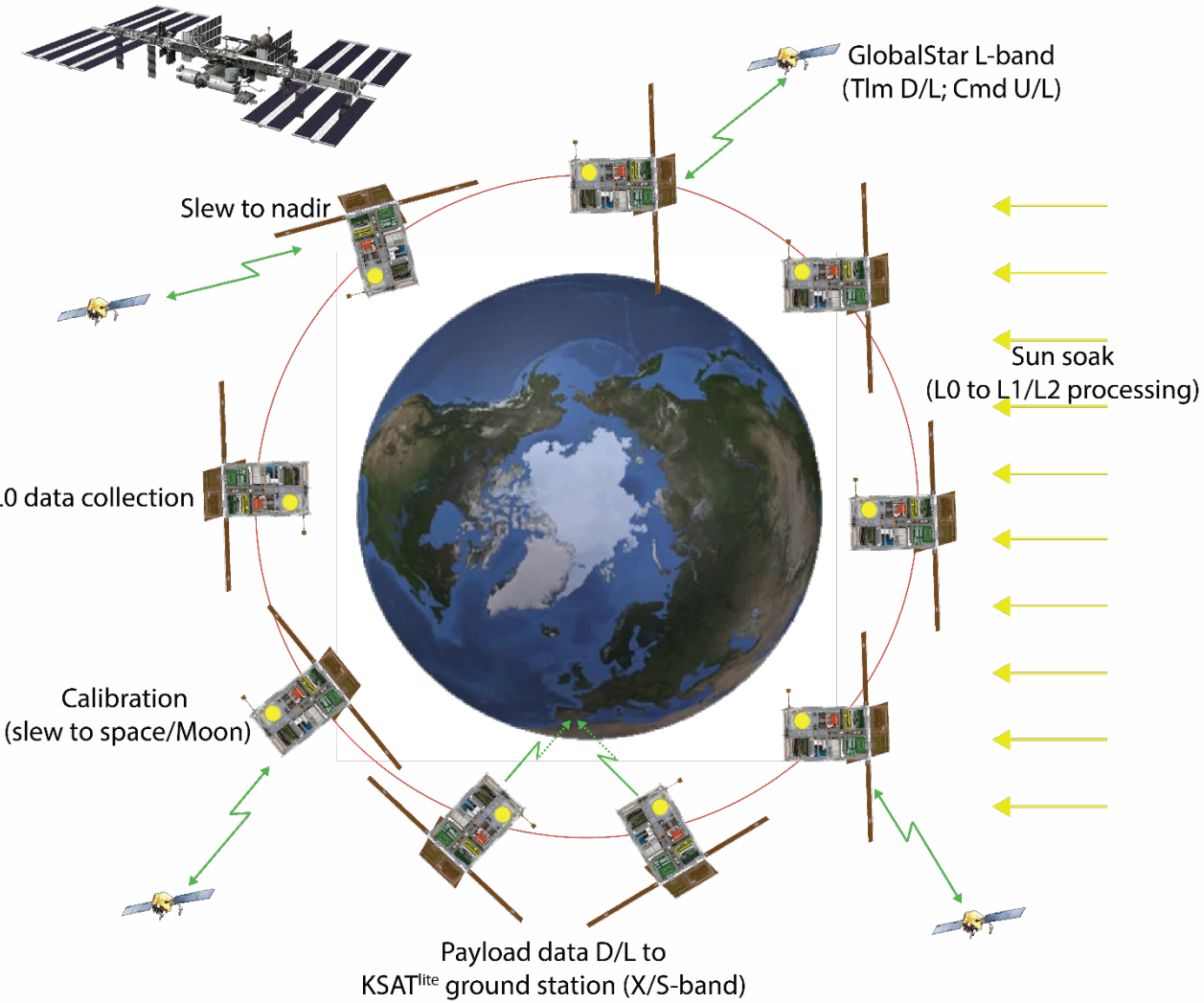


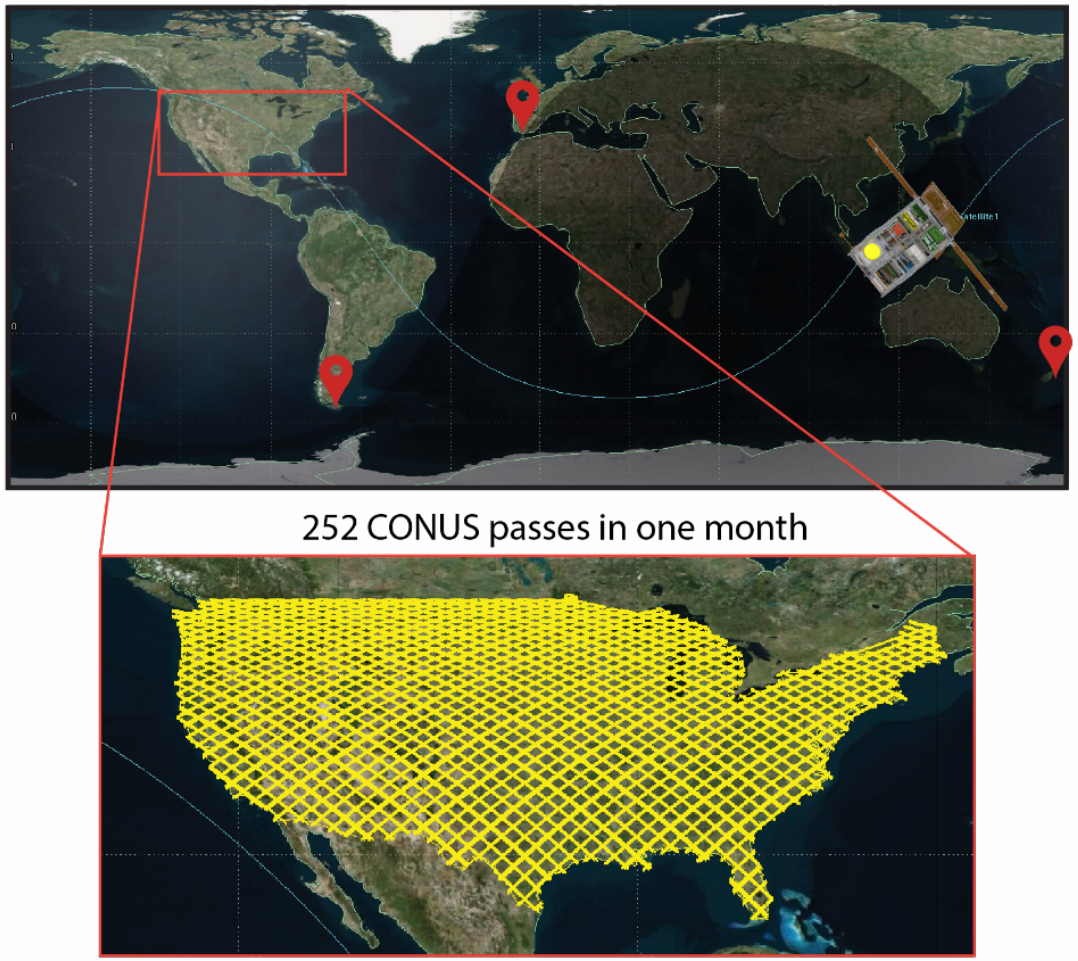
Attitude determination and Control (TRL=9)
- Reaction wheels (CubeSpace CubeADCS) TRL=9
- Torque rods (CubeSpace CubeADCS) TRL=9
- Star Tracker (CubeSpace CubeStar) TRL=9
- Nadir sensor (CubeSpace CubeSense) TRL=9
- Sun sensor (CubeSpace CubeSense) TRL=9
- Magnetometers (CubeSpace CubeADCS) TRL=9
- ADCS OBC (CubeSpace CubeComputer) TRL=9
- GPS (NovAtel OEM719-GSN-LNN-TBE-H) TRL=9

Electrical and Power (TRL=5)
- Solar panels (×4 ISIS iSPA) TRL=9
- Power distribution and battery pack (ISIS iEPS) TRL=5

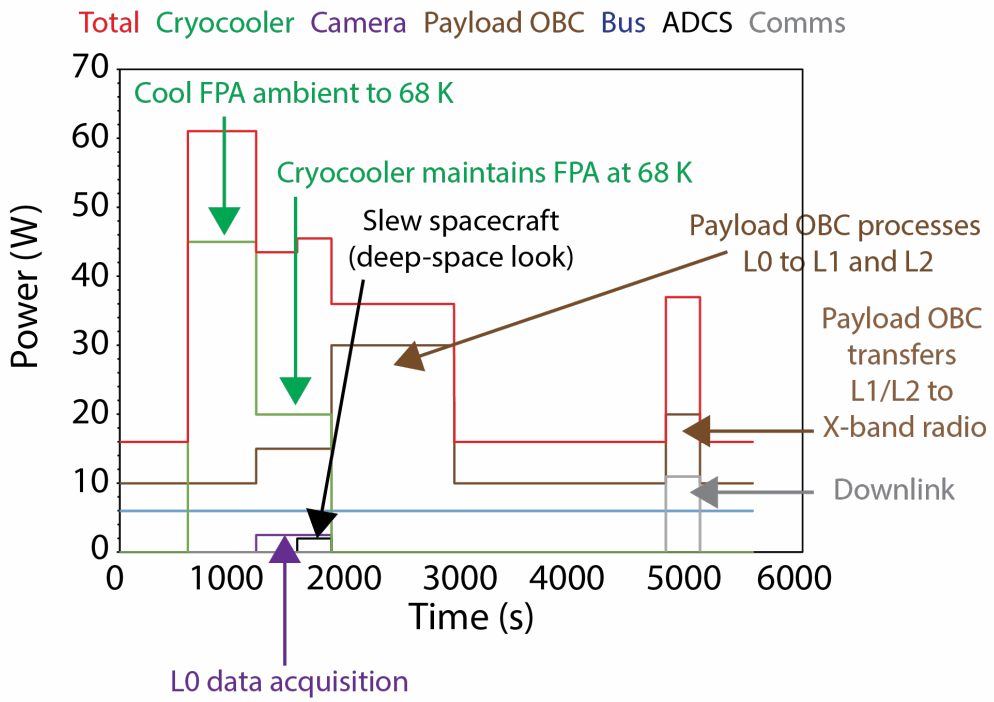
A Day-in-the-Life of HyTI

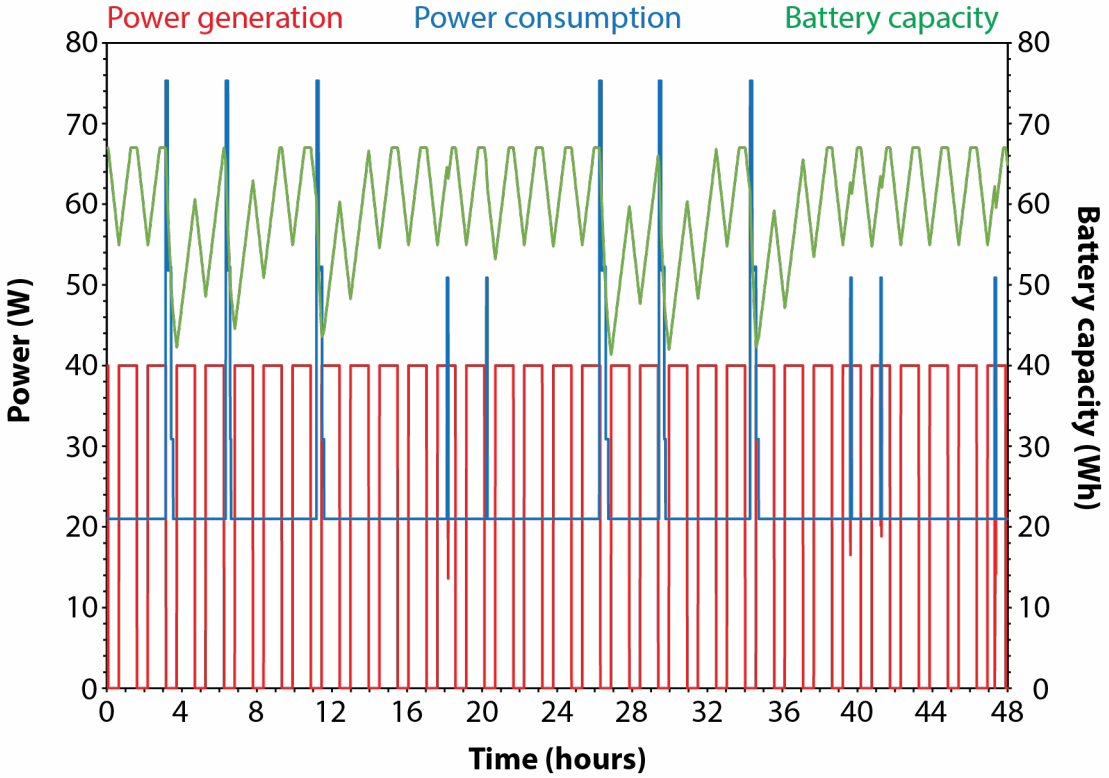
HyTI
Hyperspectral Thermal Imager





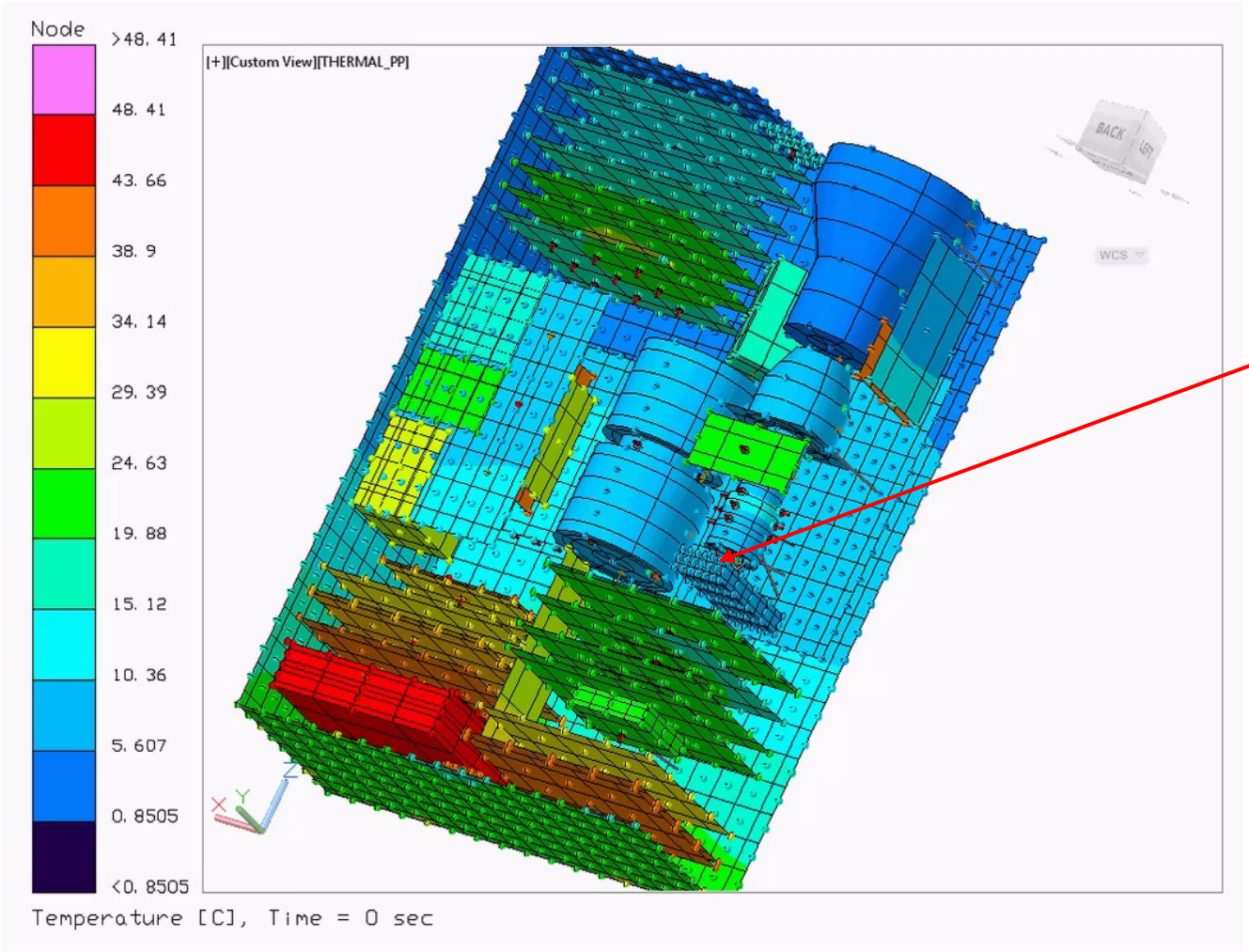
HyTI Power Budget

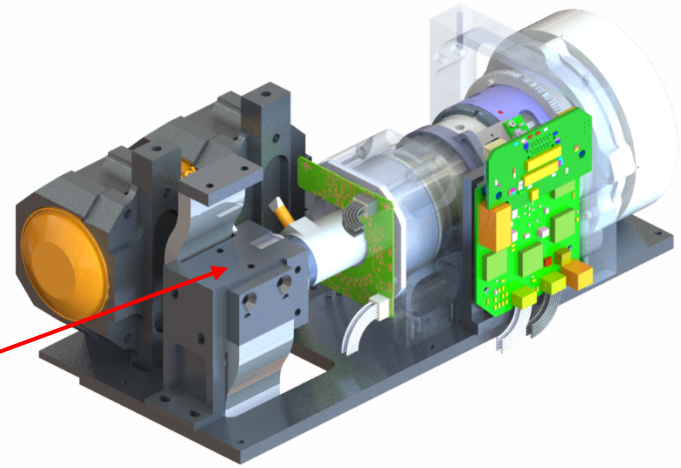


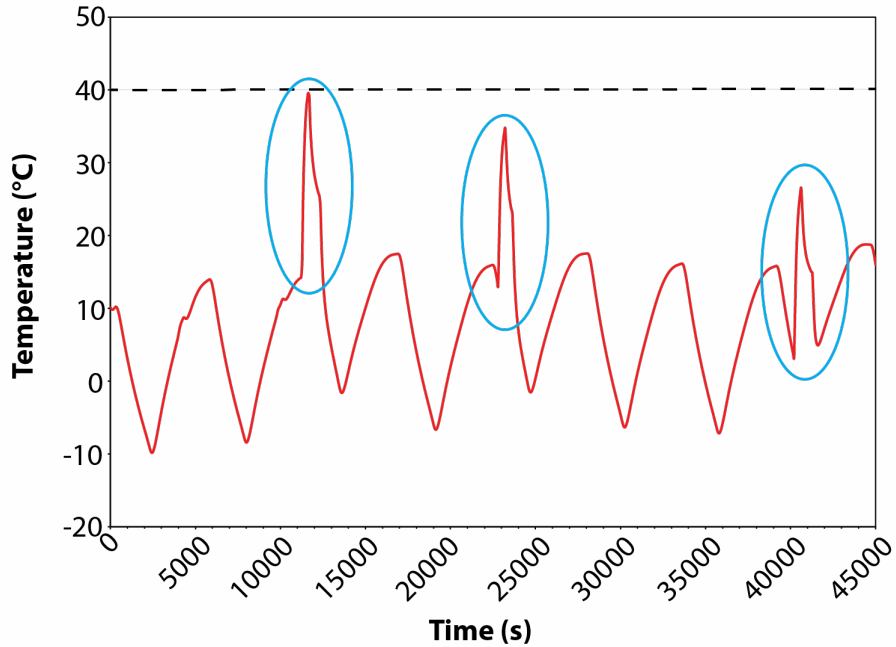


HyTI Thermal Control

HyTI
Hyperspectral Thermal Imager

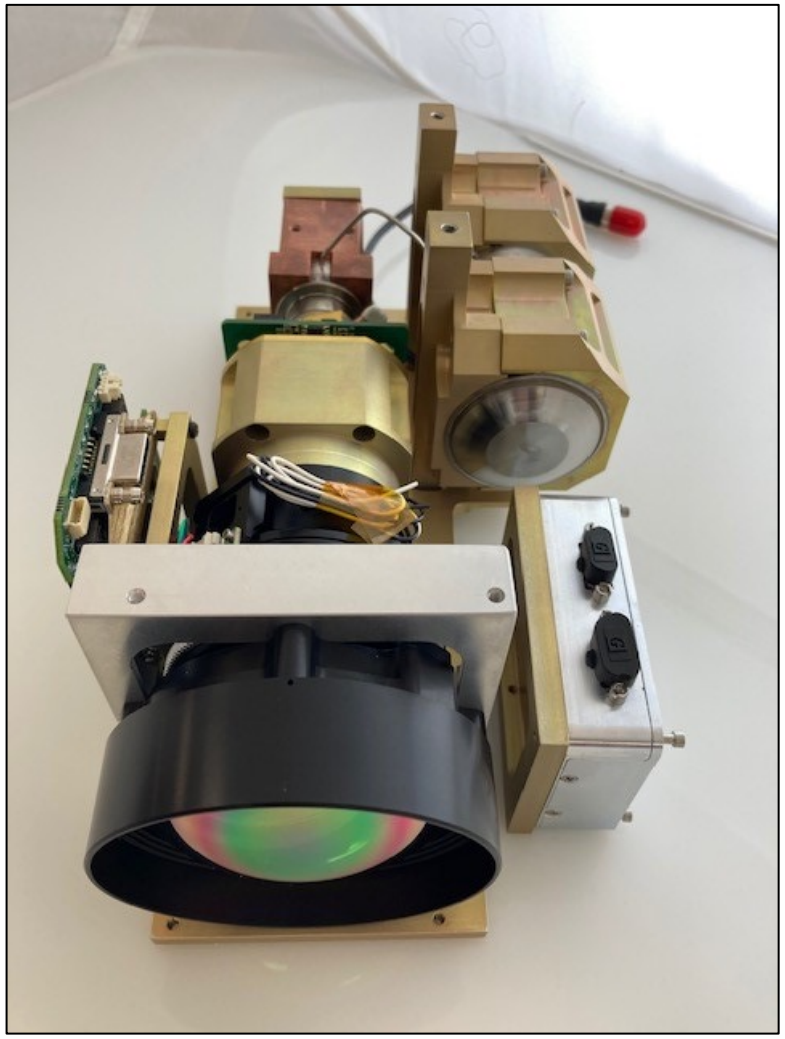


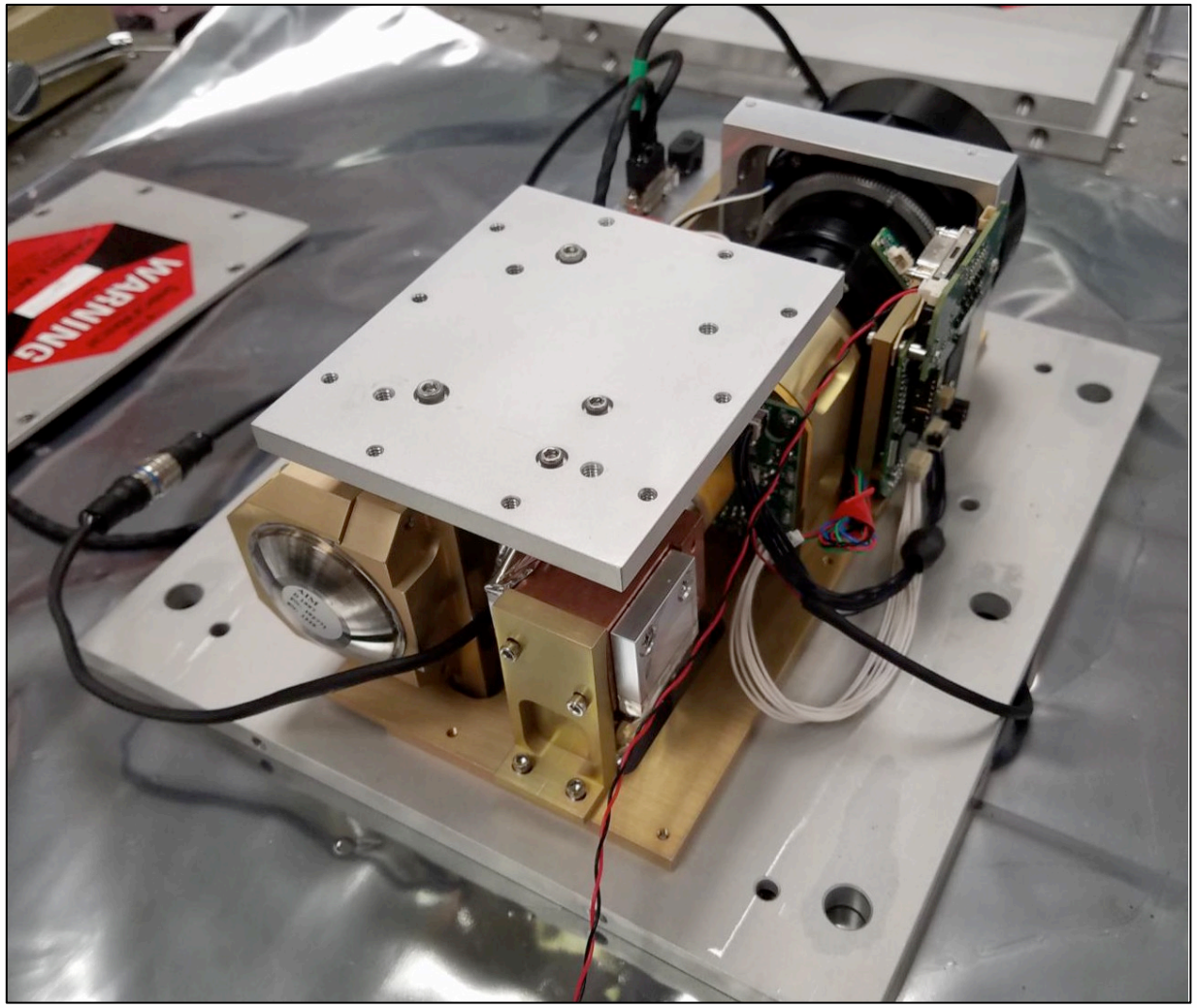




HyTI payload status

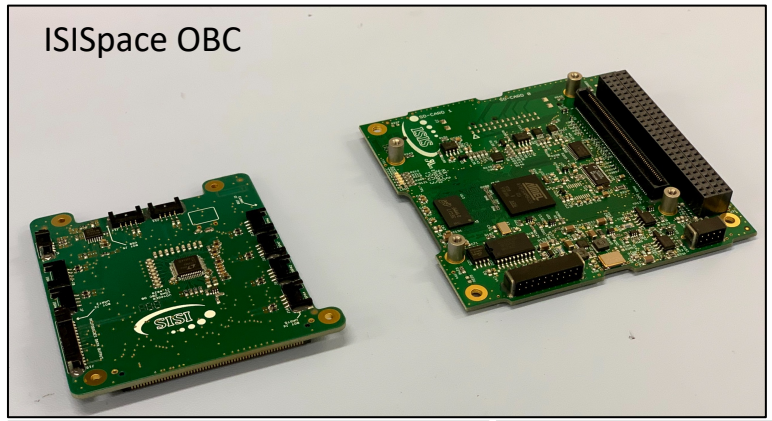
HyTI
Hyperspectral Thermal Imager

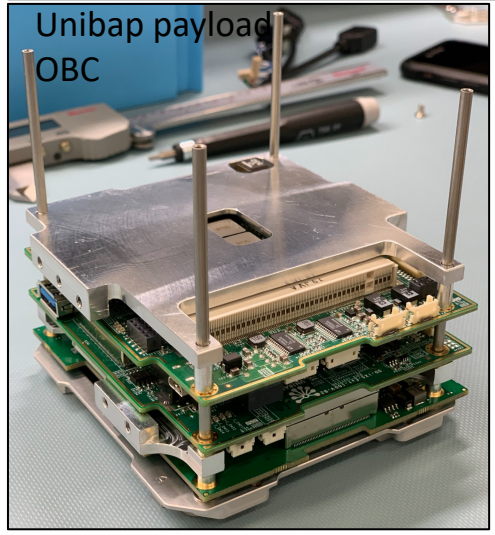


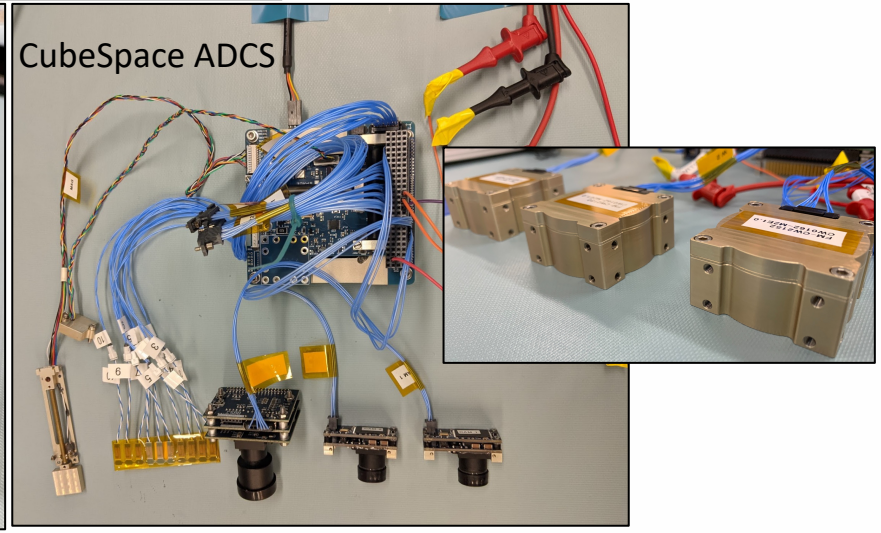


Payload shipping from AIRS to JPL next week for radiometric testing and payload-level vibe

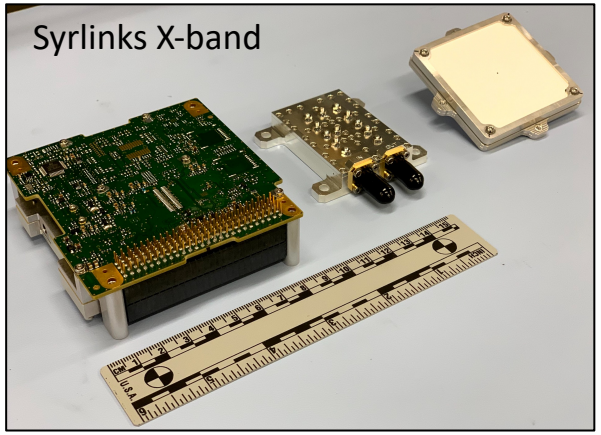
HyTI bus status

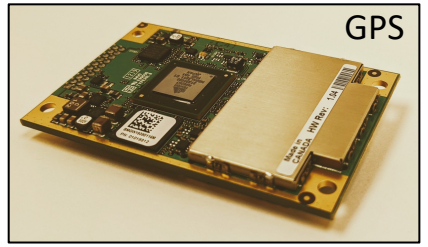




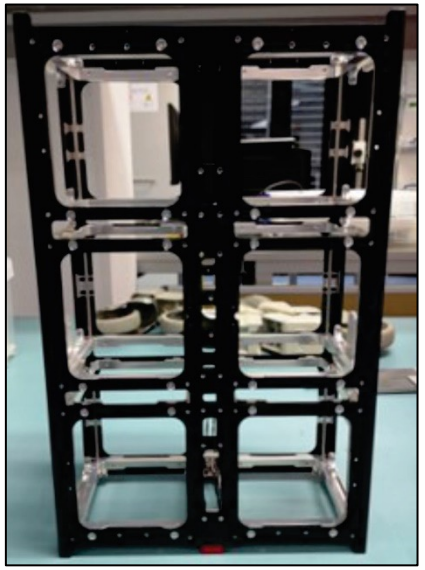


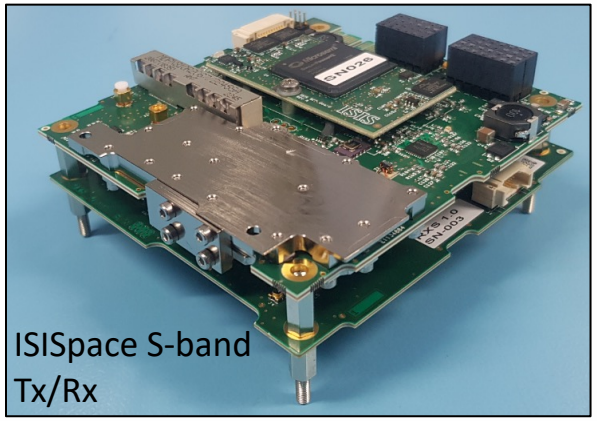
Awaiting delivery of FMs for two Creare cooler support boards (next week) and FM of ISISpace EPS (tbc)

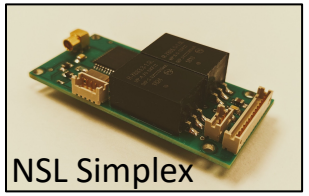


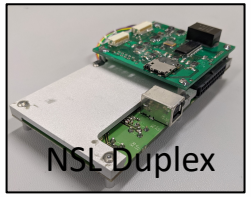


ISISpace 6U structure

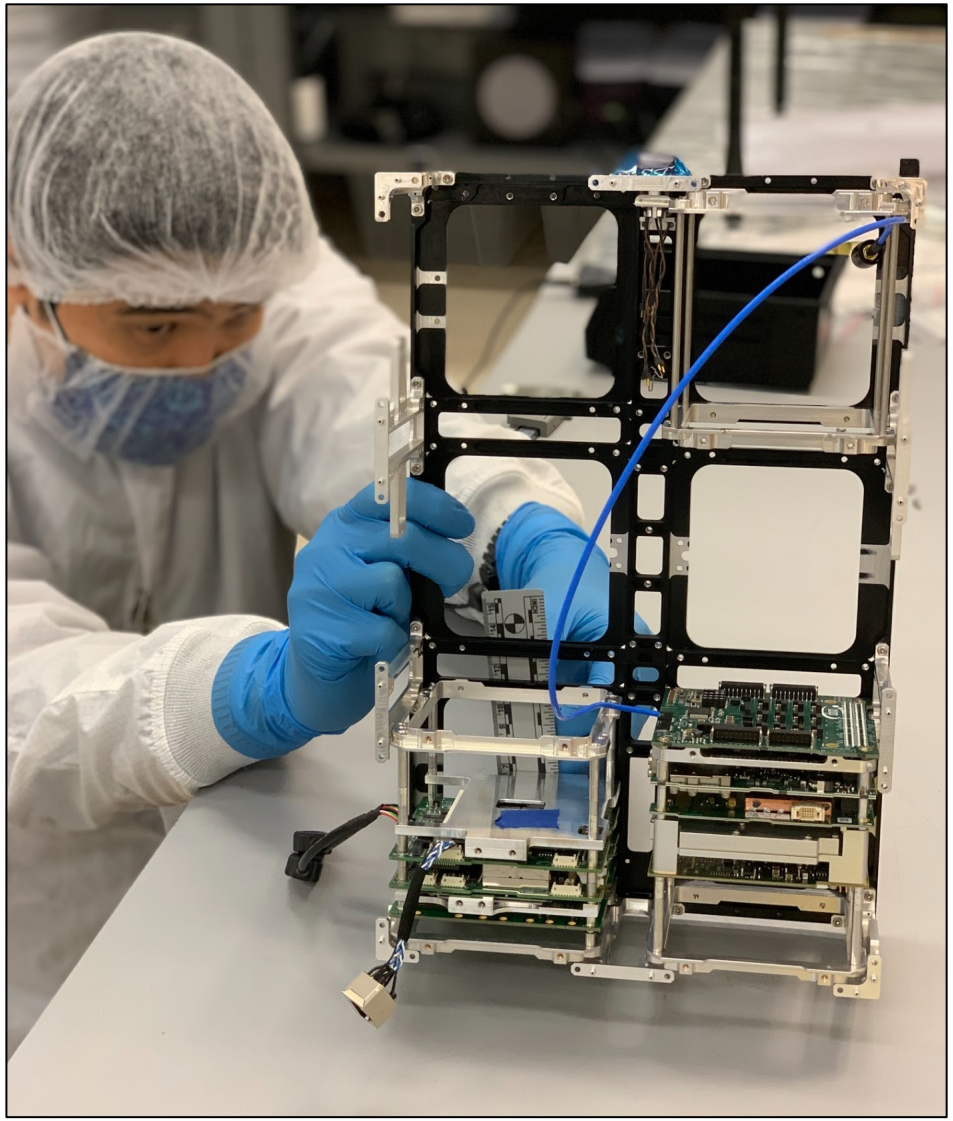


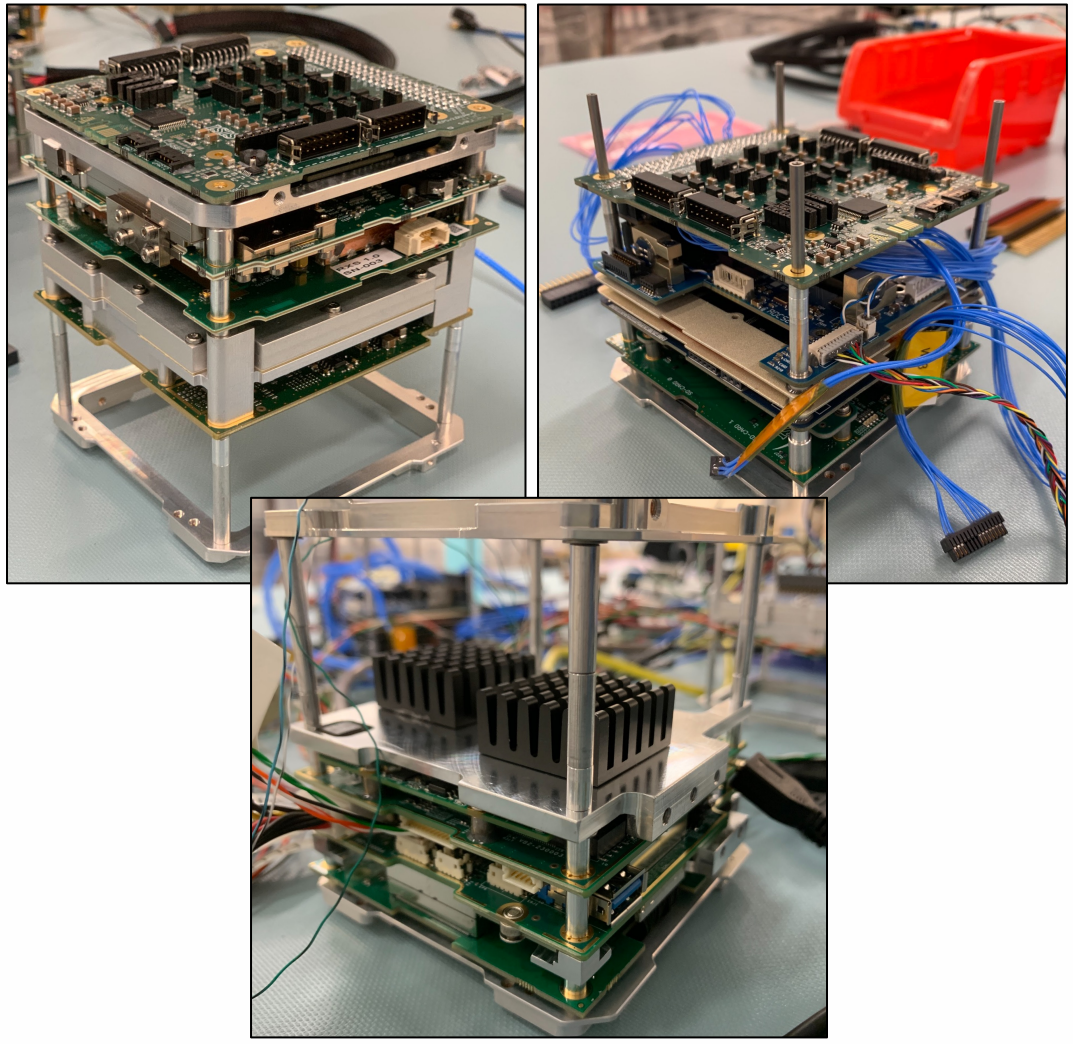






HyTI bus status

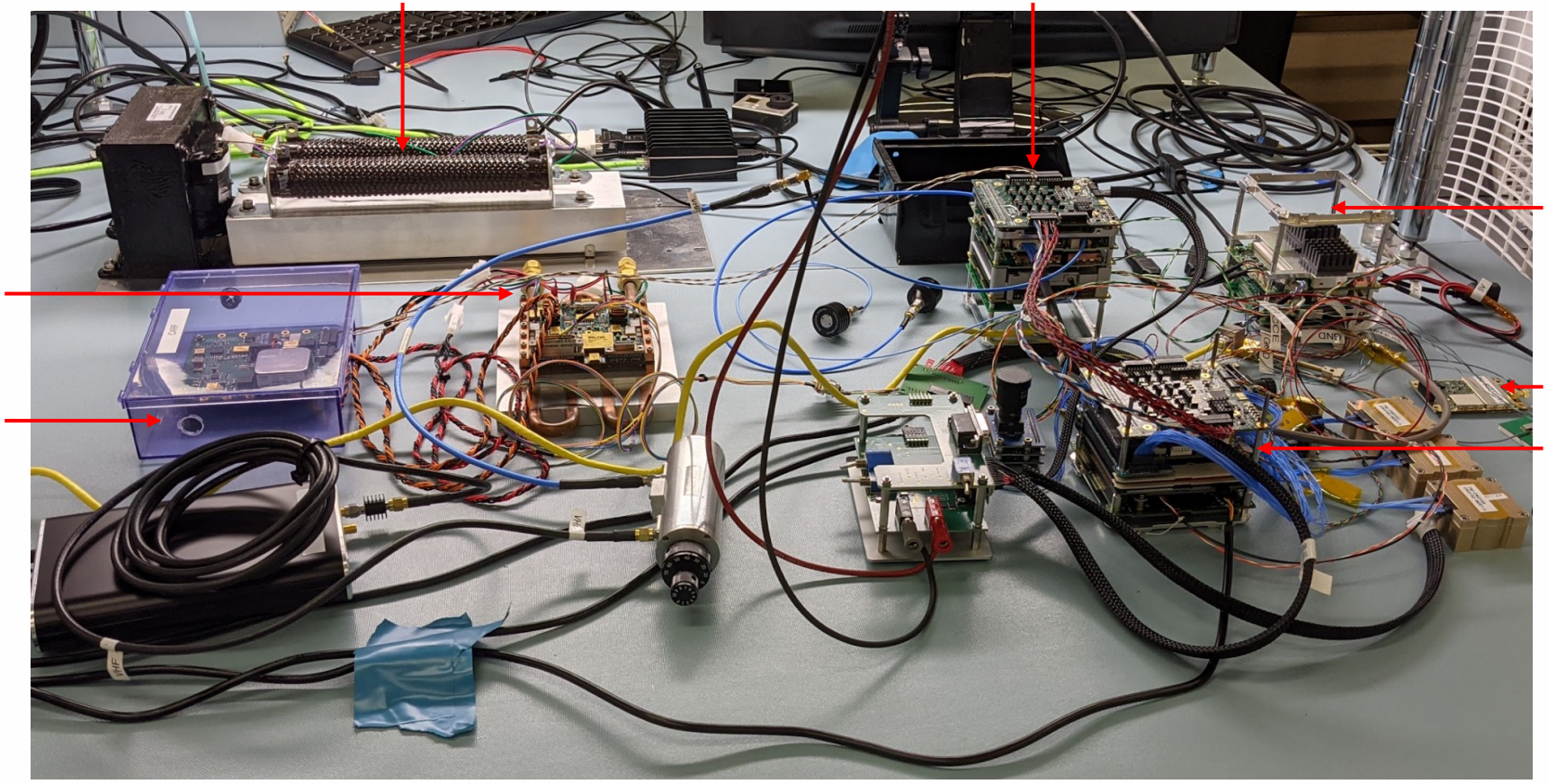




Fit-check/populating frames

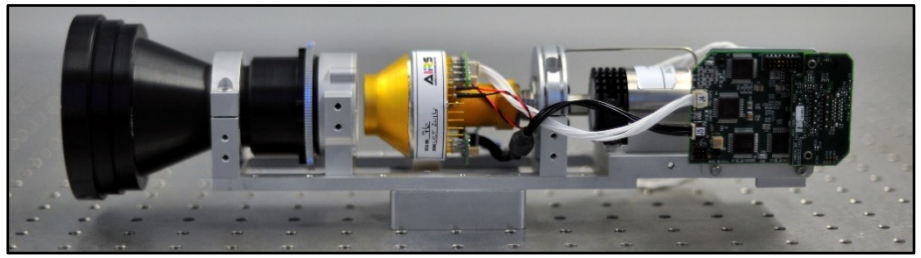
HyTI bus status – current flat-sat

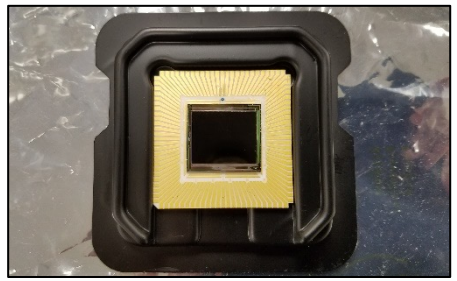
Hyperspectral Thermal Imager

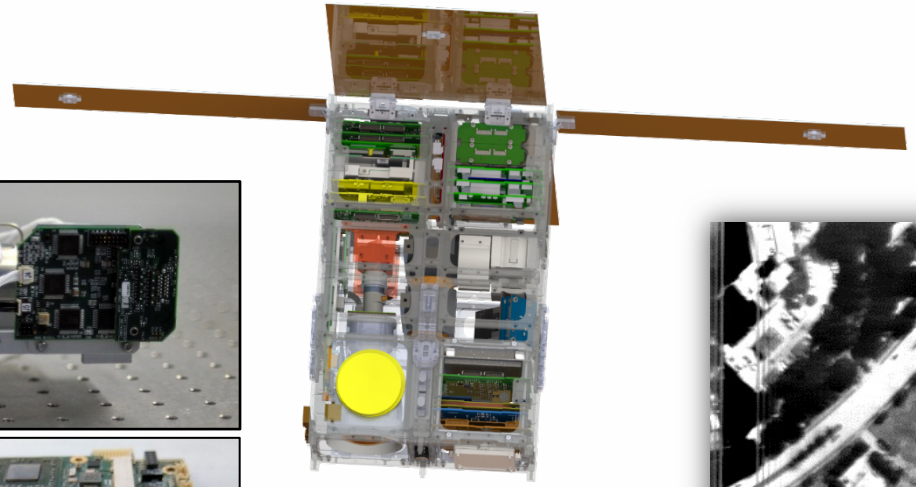


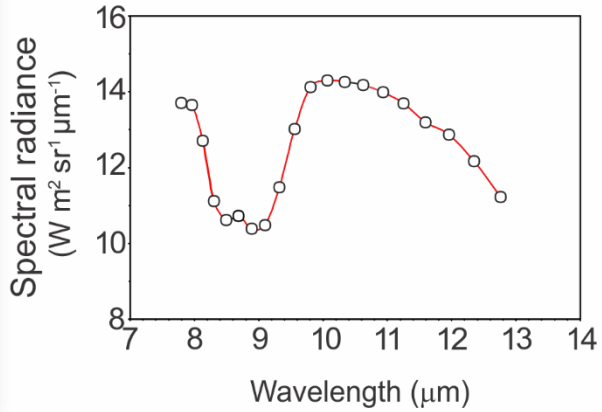
Summary

HyTI
Hyperspectral Thermal Imager









- **Space-validating innovative new technology to provide Earth scientists with high spatial and spectral resolution thermal infrared image data from a 6U CubeSat**

- **Delivery to Nanoracks by 1 October 2021**

Acknowledgements:

1. Funding from *NASA's Earth Science Technology Office's InVEST program* (80NSSC18K1601), and Sachi Babu (Program Manager)
2. Co-Is and collaborators: Paul Lucey, Miguel Nunes, Luke Flynn (UH Mānoa); Sarath Gunapala, Sir Rafol, David Ting, Alex Soibel (JPL); Lloyd French (Qwest Inc.); Carl Kirkconnell (West Coast Solutions); Dan Manitakos and Bob Papinsick (AIRS), Tom George (SaraniaSat); Peter Kornick, Greg Fitzgerald and team (FLIR OSG); ISISpace; Death Star Developments